Neural network for classification waters sample of shatt al Arabe River

Entesar B.Tala, Wesal Fakhri Hassan, Hala Ali Shabar, Eman Thabet, Donia Kassaf Al – khuzie

Department of Computer Sciences, College of Education for Pure Sciences, University of Basrah, Basrah, Iraq

College of Marine Sciences, University of Basrah, Basrah, Iraq

Marine Science Center, University of Basrah, Basrah, Iraq

Received 20-12-2021, Accepted 09-03-2022, published 31-05-2022.

DOI: 10.52113/2/09.01.2022/12-19

In this study, we develop an automated system that uses a collection of attributes to classify water samples from the Shatt al Arabe River (EC, Cl, Ca, Mg, Na, and SO4). There are three steps to the water categorization system: First and foremost, in this manner from October 2009 to September 2020, water samples were taken monthly from eight locations along the Shatt Al-Arab River in Basra. Qurna, Tubular Bridge, Al Muzairah (station 1), Saad Birdge (station 2), Al-Karma (station 3), Al-Sandbad (station 4), Al- Ashar (station 5), Abo Al-Kasseb (station 6), Al-Seba (station 7) and Al-Foa (station 8) are among these locations (station 8). Second, using established procedures, measured and analyzed chemical elements such as electrical conductivity (Ec), chloride (CL), calcium (Ca), magnesium (Mg), sodium (Na), and Sulphate (SO4). Finally, there are neural networks with three hidden layers are used for training and testing purposes. The experimental results on the collected database show that the proposed approach achieves high accuracy in automatic water classification (normal and abnormal). The Project is designed by Matlab.

Key word: Neural network, Classification, Shatt Al Arab River.

1. INTRODUCTION

In recent years, Shatt al-Arab has suffered from the problem of pollution caused by the dumping of industrial, agricultural and household wastes directly affecting its quality and use. The most prominent of these pollutants are hydrocarbons, pesticides (pesticides) and heavy metals [1, 2].

Several factors have contributed to the deterioration of the water quality of the Shatt al-Arab and its tributaries, including the construction of dams in the upstream countries[3] the closure of the Karun and Karakha rivers [4] Water Resources in the Southern Region, Solid Waste and Industrial Liquid, Insecticides and Residues of Massacres, Fertilizers and Fertilizers [5]. The most important results of the pollution of the Shatt al-Arab water led to an environmental disaster suffered by the southern region has been affected by large areas of palm groves and the spread of many diseases and serious epidemics and low productivity of agricultural soils [2].

The Shatt Al-Arab River is used for a variety of uses, including drinking, irrigation, and as a habitat for a variety of creatures. Most rivers and streams have become tourist destinations and activities due to their scenic qualities [6]. Surface water is generally used as the primary source of water for the provision of potable water in most nations across the world following necessary treatment. When high-quality water is used as a source, treatment costs for potable water production are considerably reduced [7]. As a result, freshwater sources such as rivers and streams must be preserved from
contamination, not only for human benefit but also to minimize environmental degradation and biodiversity loss. Water quality refers to the chemical, physical, and biological characteristics of water, as well as an assessment of its state in relation to human needs [8]. It is used in conjunction with a set of standards that can be used to measure compliance. The accepted standards for assessing water quality are concerned with ecosystem health and the safety of human usage [9]. It is possible to evaluate compliance. Water classification system will be very helpful in many applications. For example, water classification can improve irrigation systems, drinking, get safe drinking water, Industry, breeding living things, etc.

There has been no clear systematic assessment of irrigation water quality during the previous century. However, the department of environmental survey and the Directorate of water resources in Basra governorate began measuring some water parameters from January 2007 to 2012 December for different sites of the Shatt Al-Arab river. Previous studies used traditional methods in the process of forecasting and determining the solid components of water [17] and sometimes using modern methods however, the percentages of achievement are few [18]. In this study, a modern prediction method, artificial neural networks, was used to predict the solid components in the waters of the Shatt Al-Arab River from the period 2009-2021, where samples were collected from eight regions. Water classification system divide to three steps, water samples were collected monthly from eight sites along Shatt Al-Arab River within Basra city, during the period October 2009 to September 2020, analyzed sample using standard methods, classification using neural network [14,18,19,21]. This research presents a water classification method based on water samples taken from eight sites along the Shatt Al-Arab River (EC, Cl, Ca, Mg, Na, and SO4) and classified using a neural network. The remainder of the paper is laid out as follows. The proposed method is described in Section 2, as well as the feature extraction procedure and categorization. The overall implementation and experimentation of the water categorization system is explained in Section 3. Conclusion (section 4)

2. **THE PROPOSED SYSTEM**

This section gives a general view of the proposed system for water classification. The structure of the proposed system is shown in Figure (1).

![Fig. (1): the essential steps of the proposed system.](image)

The proposed water classification system could be divided into the following three steps:

1. collected data
2. feature extracted
3. water classification
2.1 Data and feature extracted:
From October 2009 to September 2020, water samples were taken monthly from eight locations along the Shatt Al-Arab River in Basra (Figure 2). Qurna, Tubular Bridge, Al Muzairah (station 1), Saad Bridge (station 2), Al-Karma (station 3), Al-Sandbad (station 4), Al-Ashar (station 5), Abo Al-Kasseb (station 6), Al-Seba (station 7), Al-Foa (station 8). Water samples were taken from the river's surface in the middle. The cations and anions (Ca, Mg, Na, Cl, and SO4) were investigated using standard procedures (APHA 1992). A flame photometer was used to determine sodium levels (JENWAY PEP7). 0.01N Na2EDTA was used to titrate magnesium and calcium. Sulphate was evaluated using a turbidity technique spectrophotometer (CEIL292) and chloride was assessed by titration with 0.01N AgNO3.

Fig. (2): Map of the sampling locations showing the Shatt Arab River 2009-2021.

2.2 Water classification
The final step in the proposed system is water classification, which distinguishes between normal and abnormal samples. After obtaining feature vectors (EC, CL, Ca, Mg, Na, and SO4) and storing them in a mat file, the classification step is performed. In our approach, we use neural network (NN) as a
classification method, we can describe all those steps as follows:

Step 1: Create a feed forward neural network with three hidden layers and 150,150,150 neurons in each hidden layer. The properties of the inputs decide the input layer for the generated neural network. This net takes a feature vector as input, and we have a six-attribute feature vector. As a result, the number of neurons in the input layer is six, whereas the number of neurons in the output layer is controlled by the number of classes. Because there are two classes (normal and abnormal), the number of neurons in the output layer is two.

Step 2: Identified the critical parameter, learning rate equal to one, epochs equal to 20000, maximum number of iterations, training time infinity, data division function (divide rand), transfer function of ith layer hyperbolic tangent sigmoid transfer function is used 'tansig', linear activation function is selected for output layer 'purelin', performance function, default = 'mse' and training function is back propagation function (Scaled conjugate gradient), weight and bias is generating randomly.

Step 3: Use train data to train the network and target matrix (target matrix is matrix with two rows and sixty columns each row consists of a vector of all zero values except for a 1 in element i, where i is the class they are to represent).

Step 4: Takes the initialized neural network and simulates it with network input matrix (train data), return the indices to the largest output as class predict.

Step 5: Calculate the network performance; the outcome is the net's total accuracy.

Step 6: Using the training net and test data, simulates the neural network and returns the indices to the greatest output as class predict.

3. Experiment Results

In this paper, MATLAB environment are using to implement it, on i7 processor with the RAM of 12GB. We used data obtained from eight sites along the Shatt Al-Arab River in Basra city from October 2009 to September 2010 to test the suggested technique. Extracted features for them and stored in data base with size 32*6, where 32 refer to the number of sequence to eight sites and 6 refer to the number of features in features vector. We used cross validation (holdout) [15, 20, 16], cross validation is a data resampling method to assess the generalization ability of predictive models and to prevent overfitting, it used to divide the database to train set and test set, the best sequence to test phase and the remain for training phase (twenty four sequences used to training NN classifier and test with one sequence). The total accuracy from the NN, it equal to the ratio between the correct predict class label on all sample that test.

\[
\text{Total Accuracy} = \frac{\text{correct predict class label}}{\text{all sample that test}} \times 100\% \ldots \ldots \ldots \ldots \ldots \ldots (1)
\]
The network gives high accuracy when train and test equal to 98% with simple training time equal to (0.19 seconds) at 30 epochs, with best training performance is $3.082 \times 10^{-08}$ at epoch 30, see figure (3). While figure (4) is the view of our network and figure (5) is the snapshot generated during the training neural network using back propagation algorithm.

![Fig. (3): Neural network training performance at 30 epochs.](image)

![Fig. (4): View of neural network.](image)

![Fig. (5): Neural network training.](image)

It is noted from Table (1) that the lowest value of electrical conductivity (EC) appears in the northern stations in the upstream and gradually rises in the direction of the south towards the bottom of the river, there is a sharp increase in ST7 and ST8 in the areas which close to the sea, The minimum and maximum E.C values in this study are reached 1.40 to 60.55 dS/cm with mean ranged from $1.64 \pm 0.32$ to $42.57 \pm 25.04$ Appeared in ST1 and ST 8, respectively. So that Shatt AL-Arab is considered as a saline water comparison with other rivers in the world [10]. This wide range of variation resulted from decreasing of water discharge to the Shatt Al-Arab River from major sources the Euphrates and Tigris Rivers, which had significant declines in their discharge as a result of dam constructions in upstream countries. ((2-4).

Table (1): The Mean, standard deviation, Minimum and Maximum value of and ions Ca, Mg, Na, Cl and SO4 in study stations.

<table>
<thead>
<tr>
<th>Stations</th>
<th>Statistics</th>
<th>EC (mS/cm)</th>
<th>Cl (Mg/l)</th>
<th>Ca (Mg/l)</th>
<th>Mg (Mg/l)</th>
<th>Na (Mg/l)</th>
<th>SO4 (Mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST1</td>
<td>Mean</td>
<td>1.64</td>
<td>564.35</td>
<td>87.5</td>
<td>86.39</td>
<td>85.41</td>
<td>240.28</td>
</tr>
<tr>
<td></td>
<td>Std. Deviation</td>
<td>0.32</td>
<td>125.81</td>
<td>19.49</td>
<td>30.7</td>
<td>82.95</td>
<td>107.78</td>
</tr>
<tr>
<td></td>
<td>Minimum</td>
<td>1.4</td>
<td>465.45</td>
<td>72</td>
<td>54.68</td>
<td>69.19</td>
<td>61.84</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>2.12</td>
<td>745.5</td>
<td>116</td>
<td>123.93</td>
<td>260.09</td>
<td>461.84</td>
</tr>
<tr>
<td>ST2</td>
<td>Mean</td>
<td>8.48</td>
<td>3121.01</td>
<td>235.5</td>
<td>291.9</td>
<td>476.6</td>
<td>490.06</td>
</tr>
<tr>
<td></td>
<td>Std. Deviation</td>
<td>4.28</td>
<td>1528.87</td>
<td>81.75</td>
<td>164.82</td>
<td>174.76</td>
<td>490.06</td>
</tr>
<tr>
<td></td>
<td>Minimum</td>
<td>2.91</td>
<td>1047.25</td>
<td>168</td>
<td>82.62</td>
<td>320.86</td>
<td>412.73</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>12.09</td>
<td>4413.75</td>
<td>352</td>
<td>225.99</td>
<td>720.43</td>
<td>1379.46</td>
</tr>
<tr>
<td>ST3</td>
<td>Mean</td>
<td>10.7</td>
<td>4072.56</td>
<td>283</td>
<td>380.9</td>
<td>555.53</td>
<td>1303.93</td>
</tr>
<tr>
<td></td>
<td>Std. Deviation</td>
<td>3.59</td>
<td>1655</td>
<td>112.49</td>
<td>143.86</td>
<td>104.93</td>
<td>658.44</td>
</tr>
<tr>
<td></td>
<td>Minimum</td>
<td>5.83</td>
<td>1757.28</td>
<td>146</td>
<td>225.99</td>
<td>480.17</td>
<td>703.35</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>13.49</td>
<td>5483.75</td>
<td>404</td>
<td>534.6</td>
<td>708.32</td>
<td>1993.95</td>
</tr>
<tr>
<td>ST4</td>
<td>Mean</td>
<td>9.79</td>
<td>5071.19</td>
<td>200</td>
<td>261.27</td>
<td>392.62</td>
<td>635.38</td>
</tr>
<tr>
<td></td>
<td>Std. Deviation</td>
<td>5.36</td>
<td>3905.73</td>
<td>54.26</td>
<td>153.16</td>
<td>280.59</td>
<td>153.05</td>
</tr>
<tr>
<td></td>
<td>Minimum</td>
<td>2.59</td>
<td>860.75</td>
<td>120</td>
<td>136.08</td>
<td>55.08</td>
<td>474.24</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>14.83</td>
<td>10295</td>
<td>240</td>
<td>437.4</td>
<td>732.53</td>
<td>837.82</td>
</tr>
<tr>
<td>ST5</td>
<td>Mean</td>
<td>13.64</td>
<td>6241.25</td>
<td>170</td>
<td>400.95</td>
<td>509.66</td>
<td>721.46</td>
</tr>
<tr>
<td></td>
<td>Std. Deviation</td>
<td>6.72</td>
<td>4520.28</td>
<td>68.31</td>
<td>196.16</td>
<td>302.57</td>
<td>115.63</td>
</tr>
<tr>
<td></td>
<td>Minimum</td>
<td>4.7</td>
<td>1562</td>
<td>80</td>
<td>182.25</td>
<td>149.4</td>
<td>636.52</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>20.75</td>
<td>12425</td>
<td>240</td>
<td>696.1</td>
<td>871.78</td>
<td>892.34</td>
</tr>
<tr>
<td>ST6</td>
<td>Mean</td>
<td>17.09</td>
<td>7162.63</td>
<td>139</td>
<td>357.21</td>
<td>550.49</td>
<td>771.81</td>
</tr>
<tr>
<td></td>
<td>Std. Deviation</td>
<td>9.18</td>
<td>5299.41</td>
<td>59.27</td>
<td>116.79</td>
<td>255.83</td>
<td>84.19</td>
</tr>
<tr>
<td></td>
<td>Minimum</td>
<td>7.45</td>
<td>2343</td>
<td>80</td>
<td>216.27</td>
<td>186.75</td>
<td>666.96</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>27.45</td>
<td>14200</td>
<td>192</td>
<td>456.84</td>
<td>752.75</td>
<td>845.15</td>
</tr>
</tbody>
</table>
the dominant anions was Chloride  ranged from 465.45 to 38695 mg/l  with a general average 8205.28 ±10065.16 This high value of standard deviation is due to high dispersion values. While the dominant cations was Na (55.08 -1574.04) mg/l and the total mean 525.48±335.61 mg/l . Shatt Al-Arab is classified as marine waters indicating that sodium chloride salt is the dominant salt. The order of ions is Ca - Mg - Sodium - SO4 - Chloride at all stations, according to Hem (1992) the sea water cations and anions can be is order as: Na ˃ Mg ˃ Ca, and Cl˃ SO4 ˃ CO3. However, in fresh water is order as the following: Ca ˃ Na ˃Mg, CO3˃SO4 ˃ Cl.

These results are consistent with [2,4,11] Al-Maliky et al show (the waters of the Shatt Al-Arab River are similar to marine waters, thus giving a clear indication of the impact of the Arabian Gulf’s saline water on that river).

**Fig.(6):** Distributions of EC, Na, Ca, Mg, SO4 and Cl parameters in selection stations of Shatt AL-Arab River during autumn and winter.

The same behavior were observed in the autumn compared with winter season for each of the elements EC, Mg, SO4 and Cl values (Fig.6) , they wear also rising upstream towards the sea. While both sodium and calcium ions
showed a high concentration during the winter but they were also rising towards the downstream. These result can be agree with some studies that showed variation of the parameters were monitored during different seasons in Shatt Al Arab River [11-13]

4. Conclusion:

In this study, water samples were collected monthly from eight sites along Shatt Al-Arab River within basra city, during the period October 2009 to September 2020. Then a set of water chemical properties were measured and analyzed: Electrical conductivity, Chloride, Calcium, Magnesium, Sodium, and Sulphate by using standard methods. Neural networks with three hidden layers (150,150,160) are used for training and testing purposes with learning rate equal to one, epochs equal to 20000. The experimental results on the collected database show that the proposed approach achieves high accuracy in automatic water classification. The network gives high accuracy when train and test equal to 98% with simple training time equal to (0.19seconds) at 30 epochs, with best training performance is $3.082\times10^{-08}$ at epoch 30.

References


[10] Al-Hejuje M. Application of water quality and pollution indices to evaluate the water and sediments status in the middle part of Shatt Al-Arab River: Ph. D.
Thesis, Biology Department, College of Science, University of Basrah; 2014.


